U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject:	Action: Review and Concurrence, Equivalent Level of Safety Finding for the Embraer Model ERJ-170 FAA Project Number TC00561B-T	Date:	June 12, 2003
		Reg Ref:	§ 25.933, § 25.1309
From:	Manager, TSS Propulsion/Mechanical Systems Branch, ANM-112	Reply to Attn of:	Lanny Pinkstaff ANM-112
To:	Manager, International Branch, ANM-116	ELOS Memo #:	TC00561B-T-HPR-06

Background

Embraer declared that the ERJ-170 aircraft will not demonstrate compliance with airworthiness requirement § 25.933(a)(1)(ii), which states "The airplane is capable of continued safe flight and landing under any possible position of the thrust reverser". However, Embraer contends that the ERJ-170 aircraft thrust reverser design protects against in-flight reverser deployment to an extent that provides a level of safety equivalent to that provided by direct compliance with the rule. Compliance with § 25.933(a)(1)(ii) is intended to completely eliminate all risk of catastrophic in-flight reverser deployment from normal operation. Under § 25.933(a)(1)(ii), any residual risk of catastrophic in-flight reverser deployment would be limited to scenarios involving unusual aircraft configurations, abnormal flight conditions or inappropriate flight crew actions. Therefore, any design intended to provide an equivalent level of safety to the subject rule must limit the residual risk of catastrophic in-flight reverser deployment to a similar level.

In general, the catastrophic risks from other aircraft system hazards are identified and managed through compliance with § 25.1309(b)(1). Therefore, compliance with this standard by the means delineated in the related FAA AC 25.1309-1A should be part of any equivalent safety finding utilizing probability that a catastrophic in-flight deployment will not occur. However, as documented in the docket justification for the subject § 25.933 rule, "A review of the past operating history of airplane engine thrust reversers indicates that fail-safe design features in the reverser systems do not always prevent unwanted deployment in flight. Many of these unwanted deployments are not caused by deficiencies in design but can be attributed to maintenance omissions, wear and other factors that cannot be completely accounted for in the original design and over which the manufacturer generally has no control even when comprehensive maintenance programs are established." This perspective has been re-enforced by a recent AIA/FAA review of transport service history, which indicates that many of the reverser in-flight deployment incidents involved inadequate maintenance or improper operations. Other factors such as uncontained engine failure, unanticipated system failure modes and effects, and inadequate manufacturing quality has also played a role in inservice deployment incidents.

Therefore, in addition to the traditional reliability predictions provided in demonstrating compliance with § 25.1309, any equivalent safety finding to § 25.933 will require that the influences which could render that prediction invalid be identified and acceptable means for managing these influences be defined. To this end, compensating design assurance and continued airworthiness features must be provided.

Applicable regulation(s)
§ 25.933(a)(1)(ii) & § 25.1309(b)(1)

Regulation(s) requiring an ELOS
§ 25.933(a)(1)(ii)

Description of compensating design features or alternative standards that allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)
The thrust reverser actuation system (TRAS) architecture has three independent lines of defense (mechanical and electro-hydraulic mechanisms) to prohibit inadvertent inflight deployment of the thrust reverser sleeves. The TRAS consists of two locking actuators, one per sleeve, controlled by an isolation control unit (valve) and a direction control unit (valve) through FADEC commands and the throttle quadrant switches. The third line of defense is a cowl lock which is controlled by its own solenoid valve.

These compensating design features, i.e. the third locking device and the system architecture independence, supported by rigorous safety analysis and appropriate continued airworthiness features will ensure that equivalency is achieved.

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation
Embraer will demonstrate that the ERJ-170 aircraft is protected against catastrophic in-flight reverser deployment to an extent which provides a level of safety equivalent to that provided by direct compliance with the rule. This demonstration requires:
1) A rigorous qualitative safety analysis to show that no single failure or malfunction, regardless of the probability, can result in a catastrophic in-flight reverser deployment;
2) An average risk analysis in accordance with FAA AC 25.1309-1A, which predicts that catastrophic in-flight reverser deployment will not occur in the fleet life of the ERJ-170 aircraft;
3) A specific risk analysis which predicts that at the beginning of each flight the aircraft will continue to meet the "no single failure" criteria of analysis 1) above and that the risk of catastrophic in-flight deployment is less than $1x10^{-6}$ per flight hour. This analysis is only required if the design can have contributory faults present for more than one flight. This analysis must consider any aircraft configuration (including latent faults) anticipated to occur in the fleet life of the airplane type, which is not proposed to be precluded from dispatch by the MMEL. For the purpose of this analysis, a configuration whose probability of occurrence is greater than $1x10^{-8}$ must be assumed to occur unless a lower total fleet exposure time can be justified by prescribing either production or utilization limits. This analysis provides a previously unavailable tool to assist in the assessment of MMEL and MRB proposals; and
4) Verification that the influences which could render these predictions invalid have been identified and acceptable means for managing these influences throughout the fleet life of the ERJ-170 aircraft have been defined and implemented.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding as documented in Centro Técnico Aeroespacial Ficha de Controle Assuntos Relevantes HPR-06. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Transport Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number should be listed in the Type Certificate Data Sheet under the Certification Basis section. [E.g. Equivalent Safety Findings have been made for the following regulation(s):

§ 25.933(a)(1)(ii) Flight Critical Thrust Reverser (documented in TAD ELOS Memo TC00561B-T-HPR-06)].

Original signed by Neil D. Schalekamp *9/16/03*

Manager, TSS, Propulsion/Mechanical Systems Branch, ANM-112 — Date

ELOS Originated by: Standards Staff, Propulsion Branch	Project Engineer Lanny Pinkstaff	Routing Symbol ANM-112